HEIMDAL

1st Juli 2013

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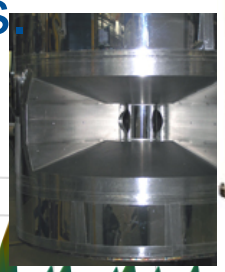
Avoid over engineering

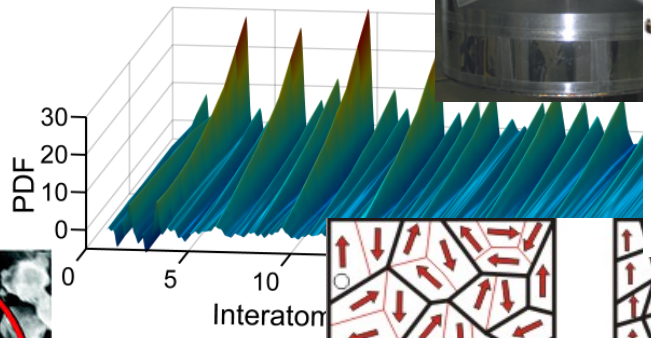
Combining too many tools makes too many compromises

Focus on selected tools and easy data access.

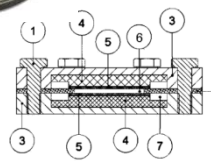
Science case

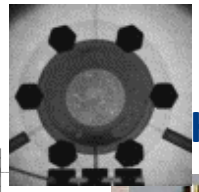
- Light elements and energy related materials.
- Composites, scaffolds or matrix embedded systems.
- Phase transition and nucleation.
- Materials with magnetic properties.



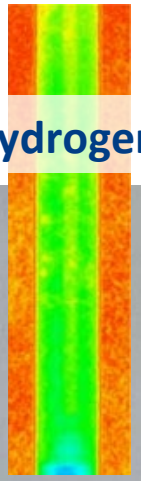


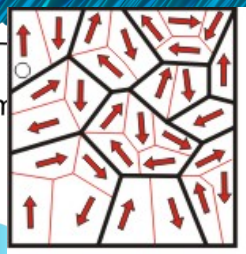
Lithium ion batteries



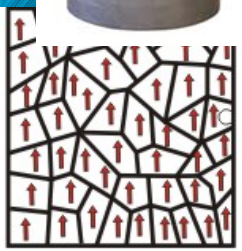


Hydrogen storage



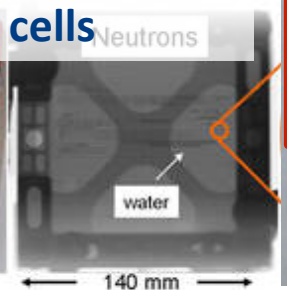


Bulk sample

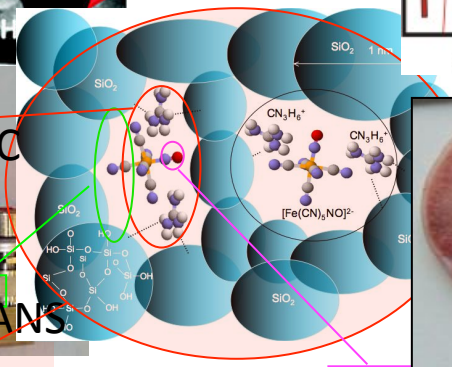


Compacted nanoparticles

Fuel cells

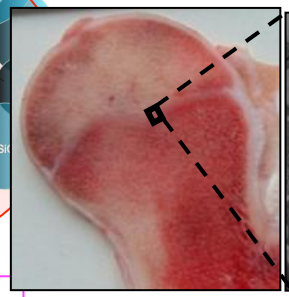


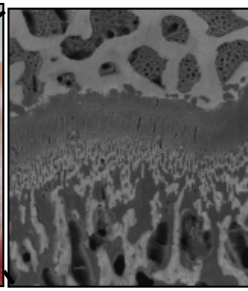
DMC



SANS

ESS Hybrid





MS/HRPT

Other hybrid instrument

The idea of combining **SANS** and **NPD** is not unique:

J-Parc has build three instruments:

Nova, I-Materia, HI-SANS

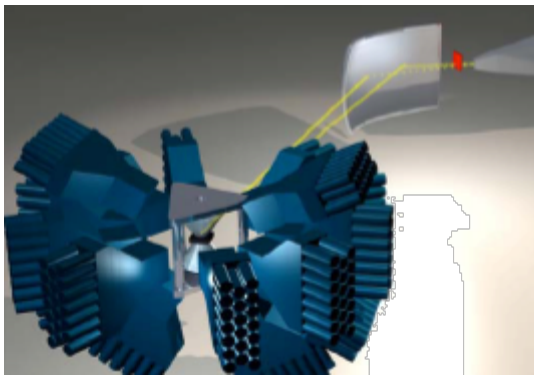
ILL have **D16** – not simultaneous coverage.

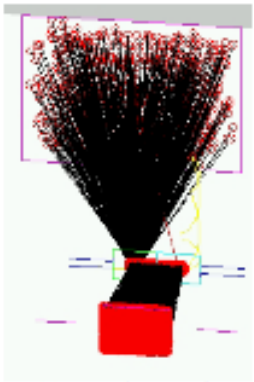
SNS planned **SANS** with diffraction detectors.

ISIS have **Nimrod.**

ISIS are building an Instrument for

NI and **NPD** at TS-2: **IMAT**

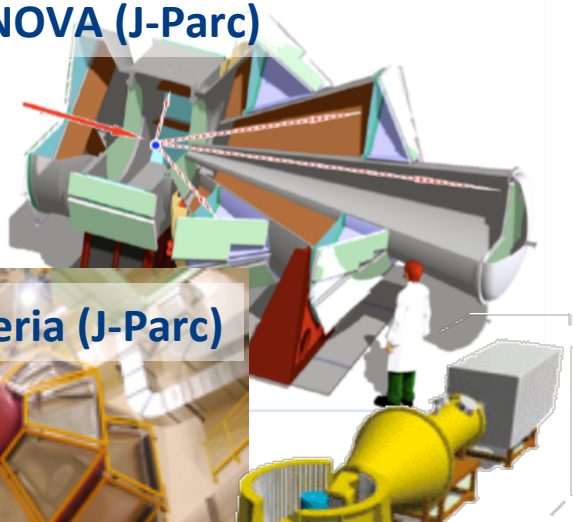


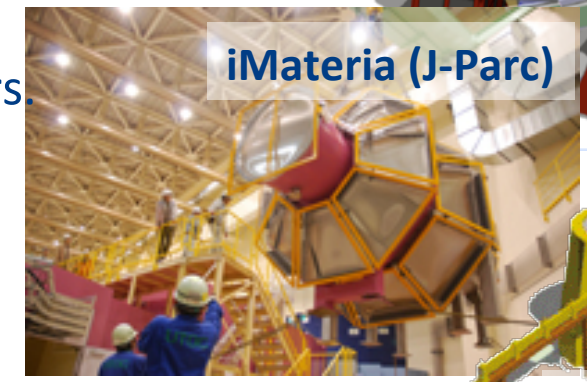


(a) Imaging mode

(b) Diffraction mode

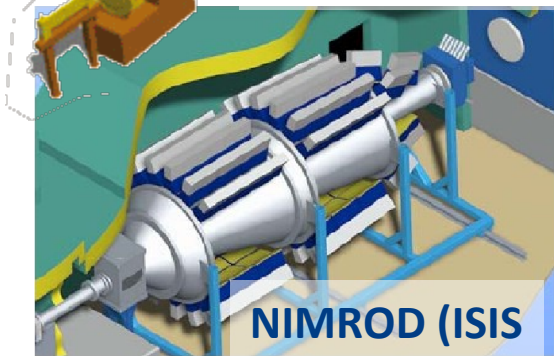
NOVA (J-Parc)





iMateria (J-Parc)

HI-SANS (J-Parc)



NIMROD (ISIS

Instruments at ESS

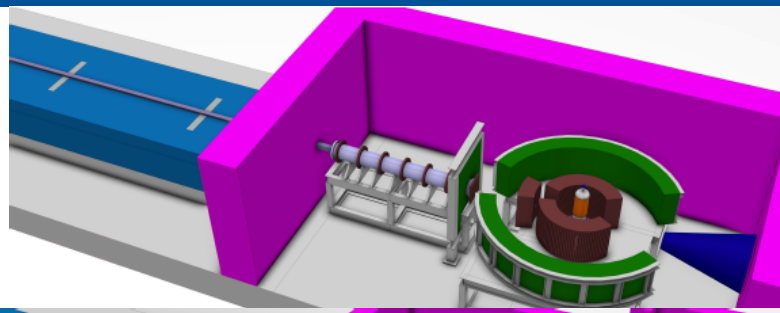
Thermal powder diffractometer

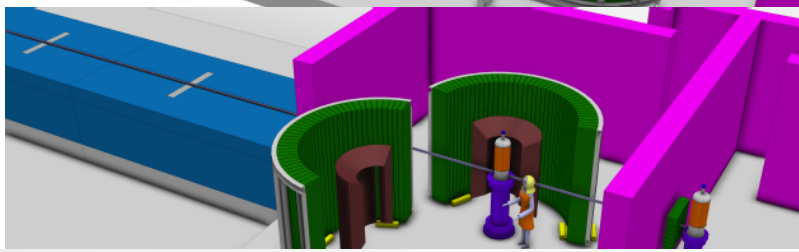
Bispectral powder diffractometer

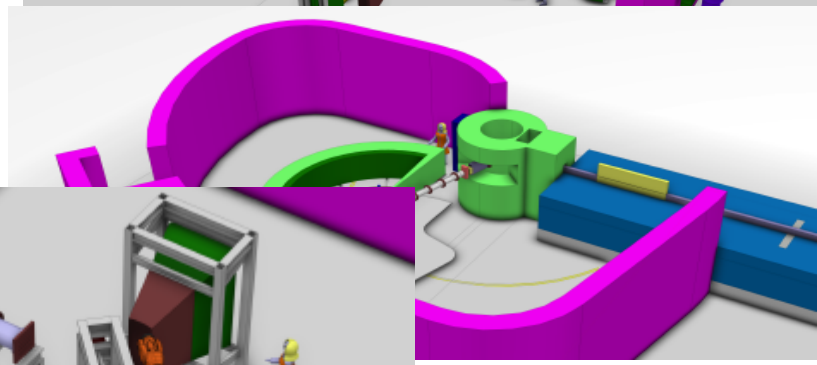
Pulsed monochromatic powder diffractometer

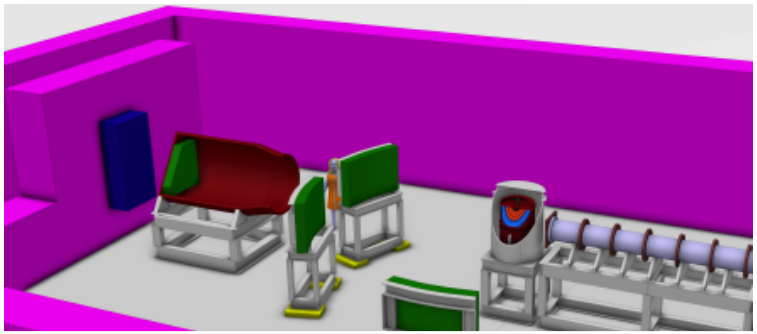
Materials science & engineering diffractometer

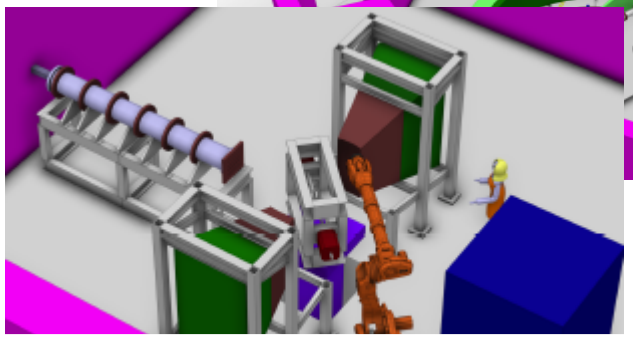
Extreme conditions instrument











TDR v3

HEIMDAL disappeared from the TDR…

Instrument concept

Cover multiple length scales:

Technique	Diffraction	Small angle scattering	Imaging
Length scale (approximate)	0.01-5 nm	1-200 nm	0.05-50 mm

Requires large coverage in reciprocal space:

Technique	Diffraction	Small angle scattering	Imaging
Reciprocal space (q)	0.5-20 $Å^{-1}$	0.001-0.2 $Å^{-1}$	NA
Wavelength band (Δλ)	0.6-4 Å	4-12 Å	NA
Resolution (Δλ/λ)	<0.5%	<10%	NA

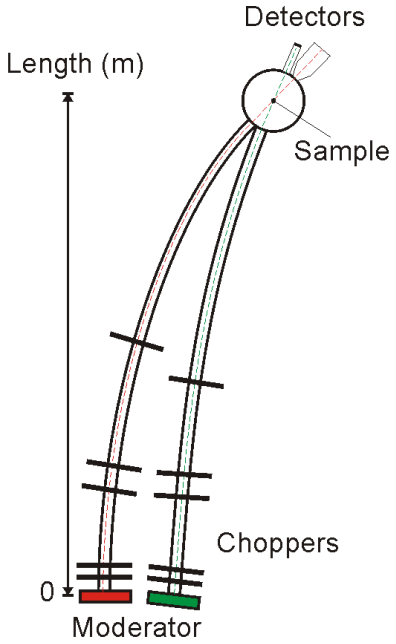
Powder diffraction favors:
Short wavelength = high q
Long instrument = resolution
Divergent beam = high flux
Can live with a narrow band

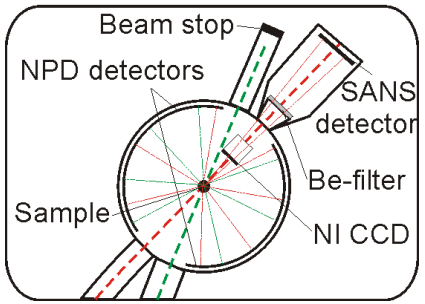
Small angle scattering favors:
Long wavelength = low q
Short instrument = broad band
Collimated beam = low q
Can live with low resolution

Different Guide Concepts

Instrument designers and potential users were invited for 2½ day workshop

2 guides are needed

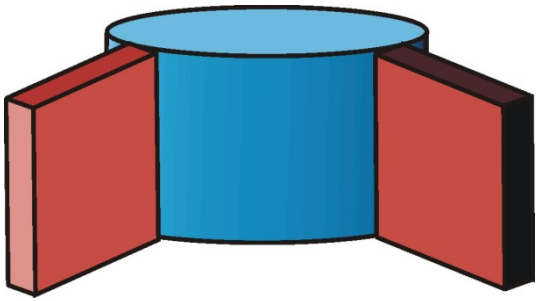


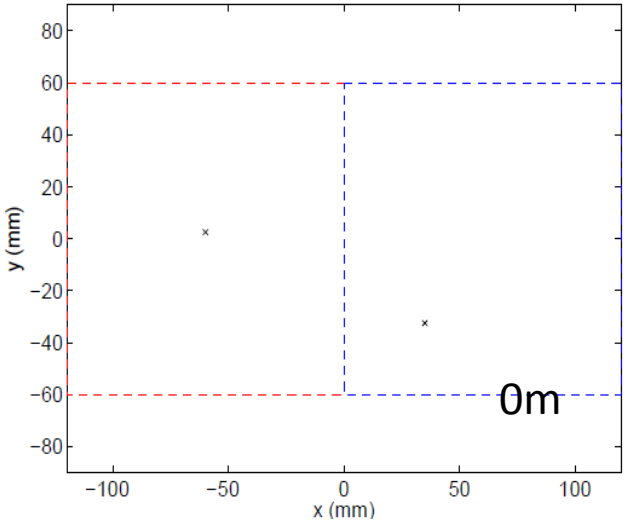


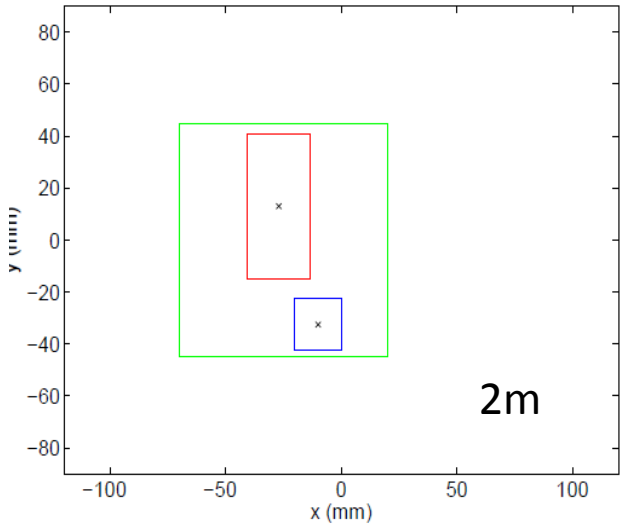
Conclusion from workshop in September 2011

Two guides from a single beamport

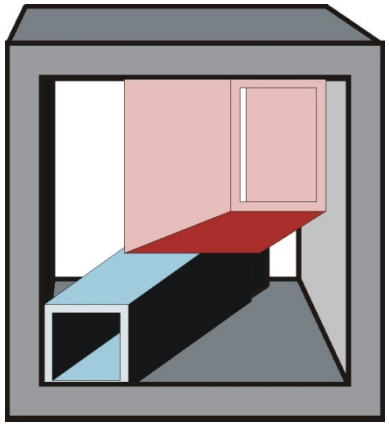
Moderator design

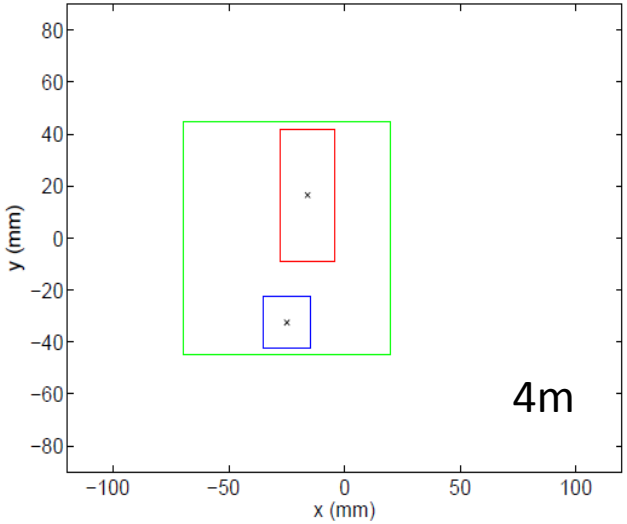


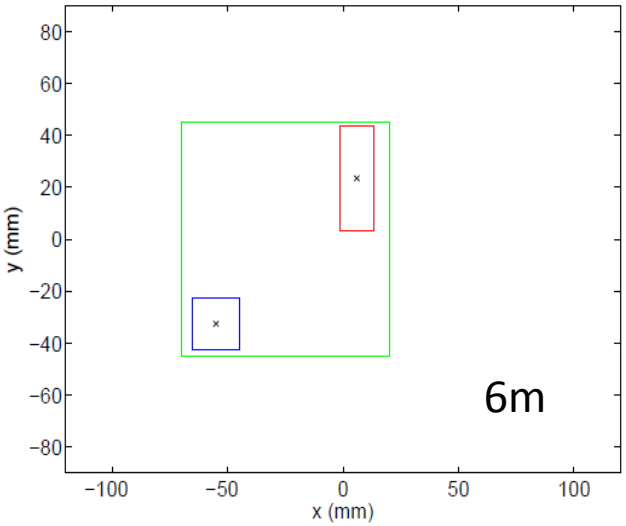




Beam extraction







Single beamport setup

Relative large curvature (R = 660 m) on cold guide

The beams meet at an angle of 5°

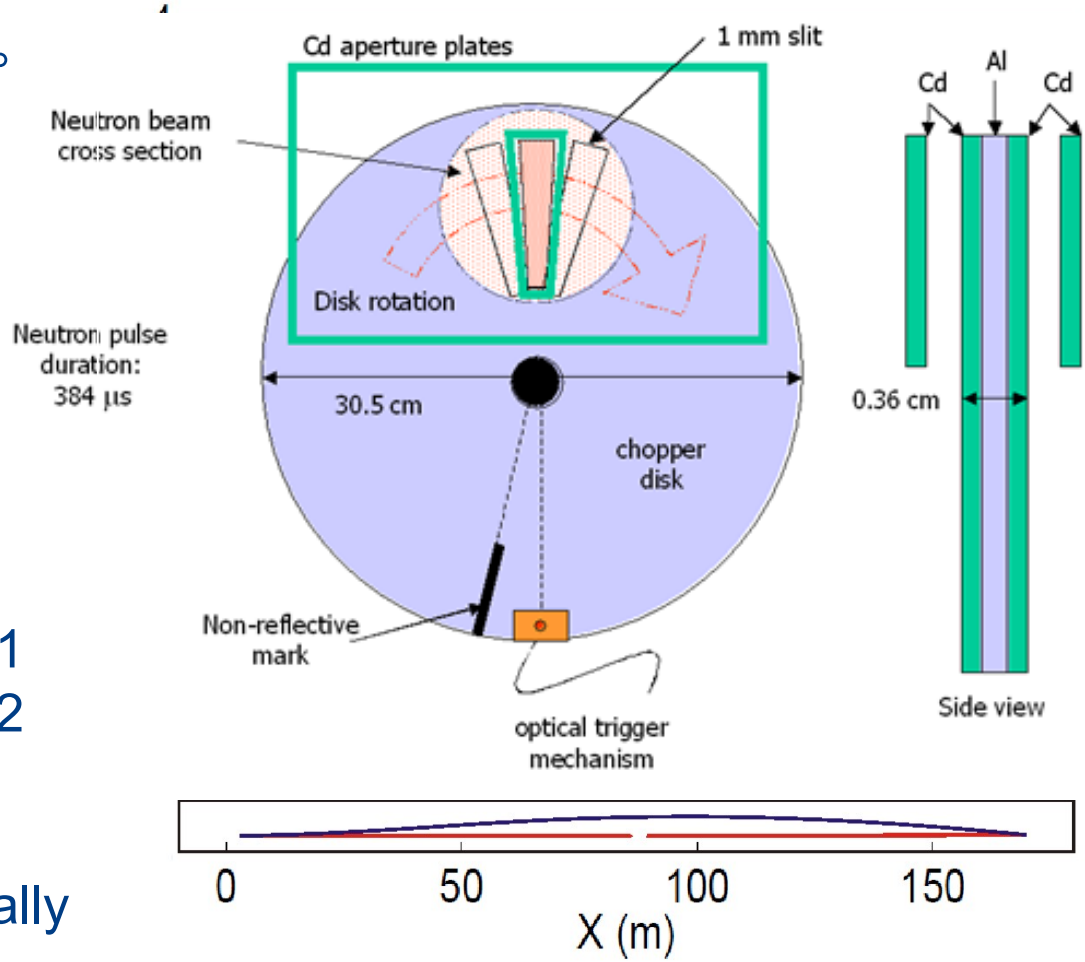
Thermal beam:

- Pulse shaping chopper
- Pulse selection chopper
- Frame overlap chopper

Cold beam:

- Band definition chopper
- Frame overlap chopper #1
- Frame overlap chopper #2

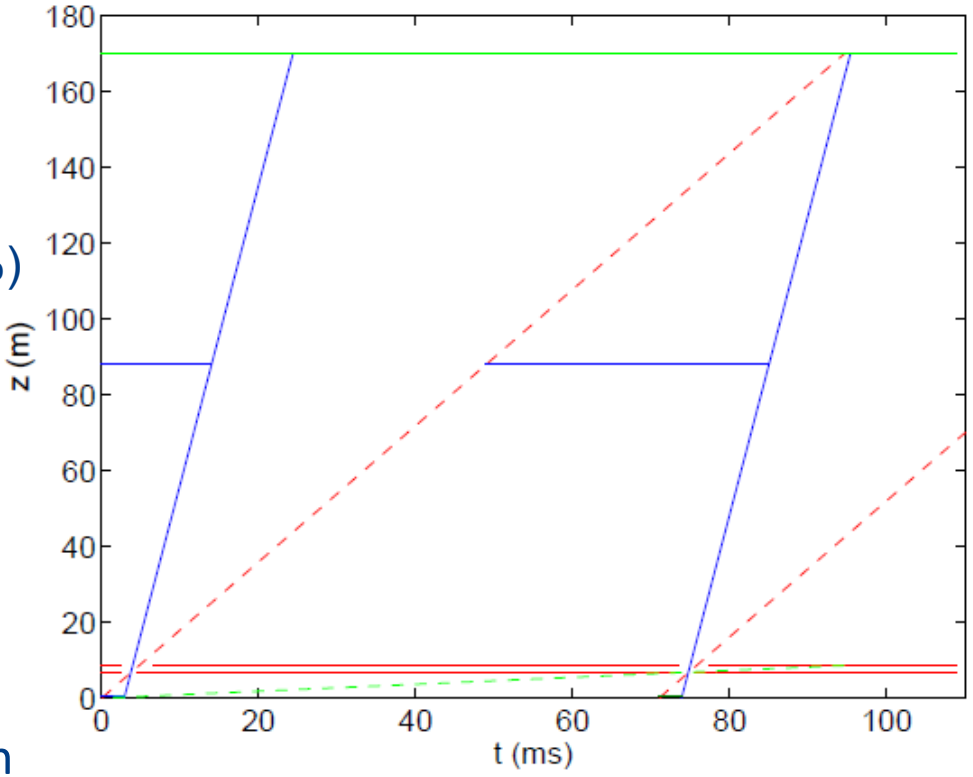
Guides can be optimized individually



Thermal chopper system

Pulse shaping chopper:

- Counter rotating double chopper
- Position: 6.5 from thermal moderator
- Frequency 280 Hz
- dt_{min} = 120 µs (4%), dt_{max} = 724 µs (25%)



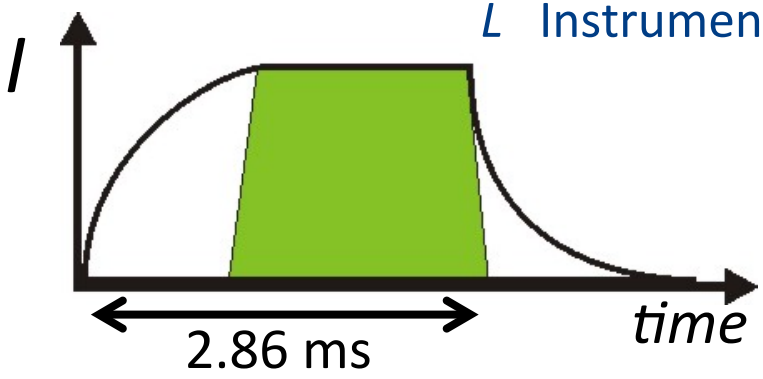
The long pulse allow trading **flux** for **resolution**

$$\Delta d/d = \tau(\alpha L \lambda)^{-1}$$

τ pulse length

λ wavelength

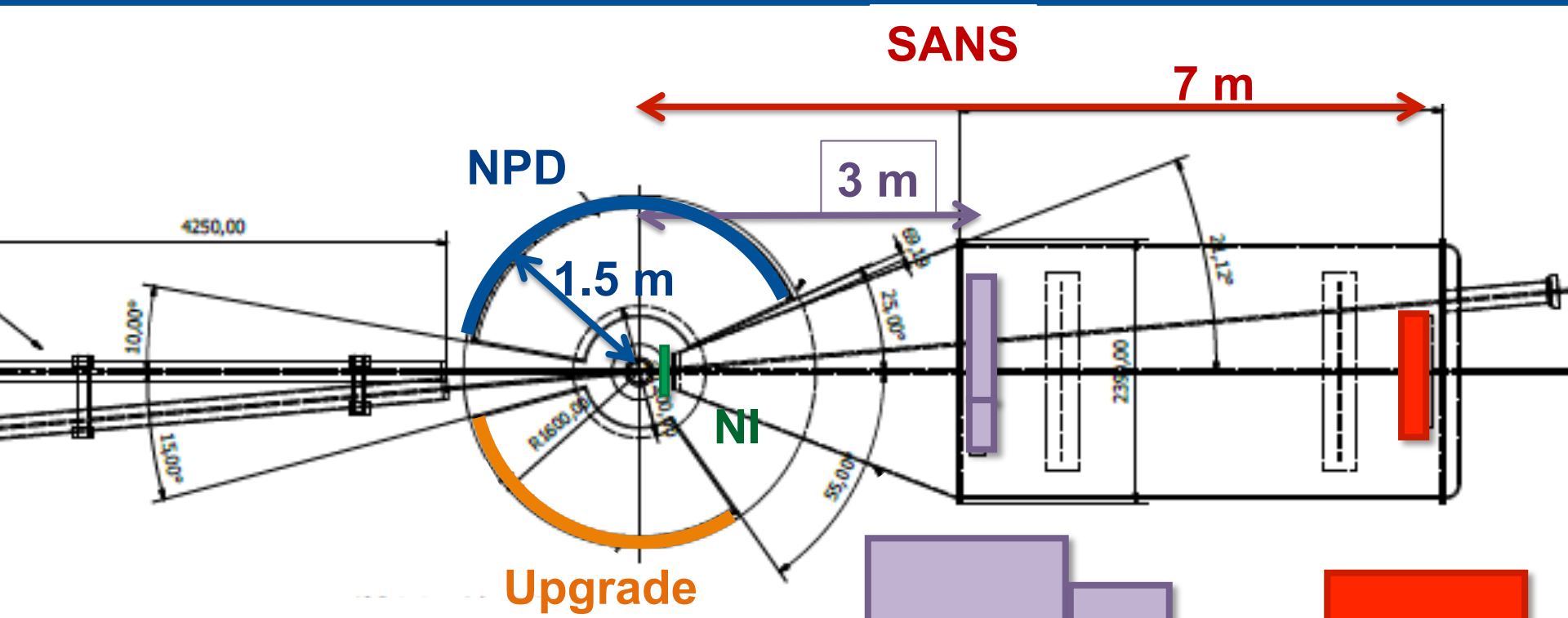
L Instrument length

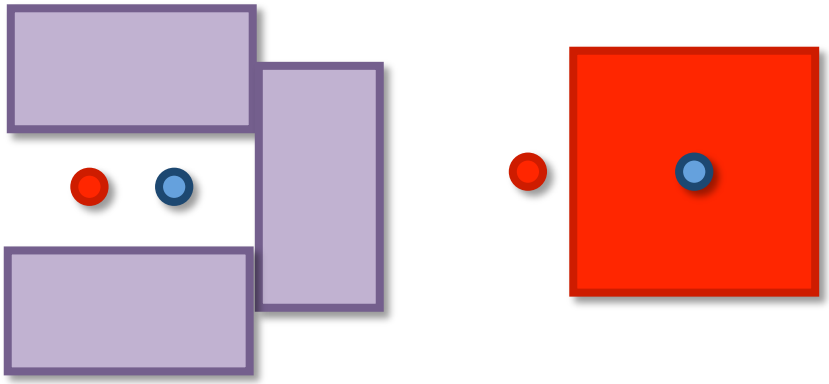


Instrument design – Who is HEIMDAL?

Ove Rasmussen, DTU-Risø

Instrument design





Q-range coverage:

Cold:	4-5.7 Å:	$3 \cdot 10^{-4}$ – 3 $Å^{-1}$
	11-12.7 Å:	$1 \cdot 10^{-4}$ – 1 $Å^{-1}$
Thermal:	0.6-2.3Å:	0.6 – 21 $Å^{-1}$

Ove Rasmussen, DTU-Risø

Sample environment

Sample access:

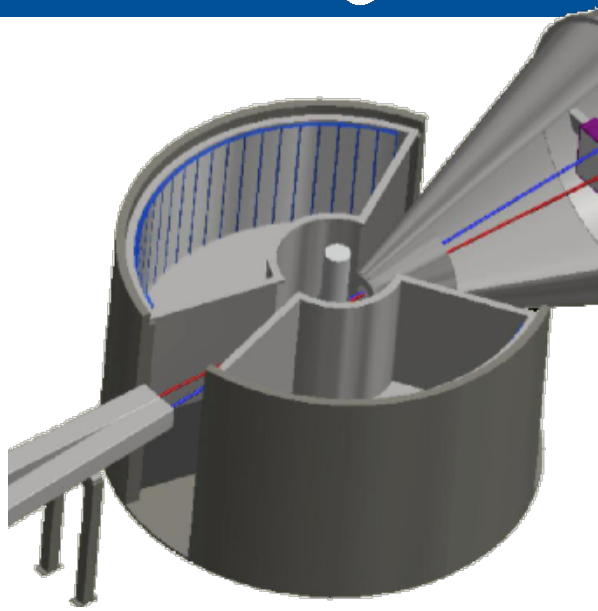
From top and bottom + side

Sample positioning:

X, Y, Z, ω

=> collect PND/SANS at different positions

=> tomography of object



Sample environment test:

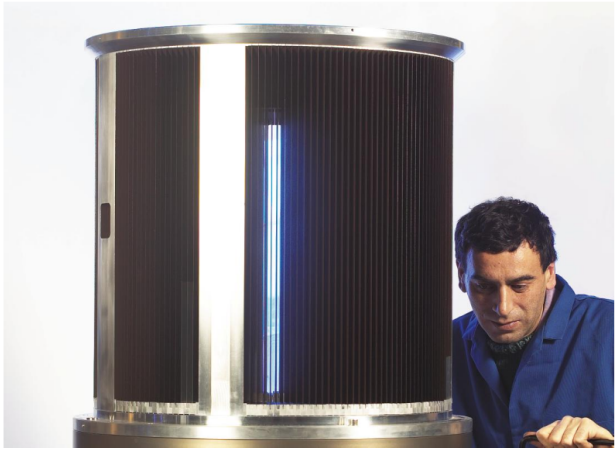
The setup can be build and tested before inserted into instrument.

Integrated optical components:

Radial collimation – different collimation

- Easy insertion/removal

Focusing optics



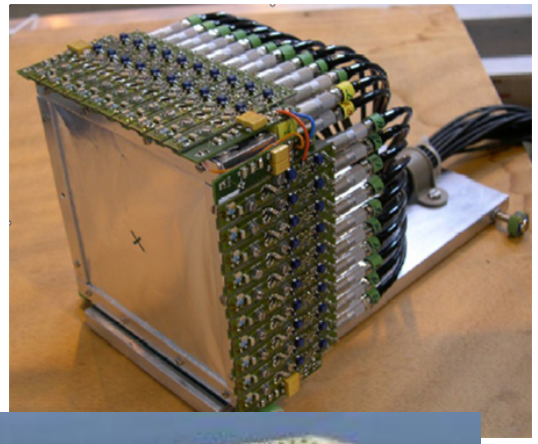
Detectors

Powder diffraction:

Scintillation detectors with avalanche-photo-diodes

Efficiency – roughly 75% of ^{3}He detector

Pixel size: 3x10 mm^2 Area ~4 m^2



SANS:

Flat panel detector – based on ESS ^{10}B development

Efficiency – remains to be clarified

Pixel size: 5x5 mm^2 Area ~2.5 m^2

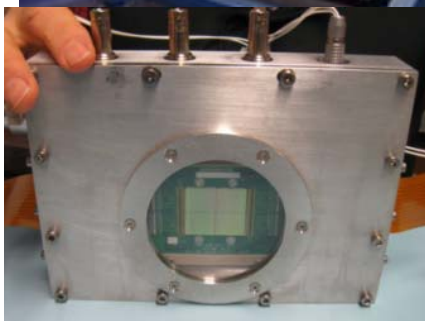
NI:

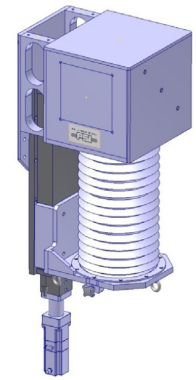
Medipix – time resolved imaging detector:

Area: 28x28 mm^2, pixel 50 x 50 µm^2

Scintillation plate, optical mirror and CCD:

Area: Variable





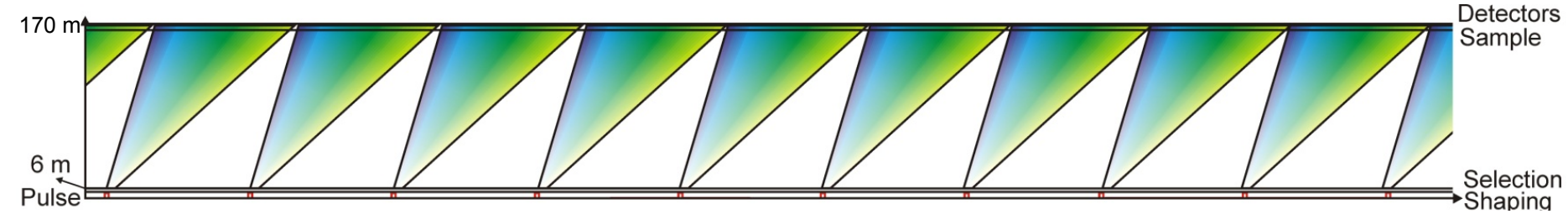
Cost

Investment	**Day 1**	**Upgrade 1**	**Upgrade 2**
Guides (thermal and cold)	3		
Shielding HEIMDAL (instrument only)	1.8	0.5	0.5
Detectors including support/vacuum chambers	5.3	2.5	2.5
Electronics	0.5	0.2	
Sample Area, Instrument Mechanics	0.6		
Choppers	0.5		
Total HEIMDAL	**11.7**	**3.2**	**2.7**
Shielding primary 5^{o} sector	1.5		
Total HEIMDAL Sector	**13.2**	**3.2**	**2.7**
Personnel			
Manpower	**1.5**	**0.2**	**0.2**

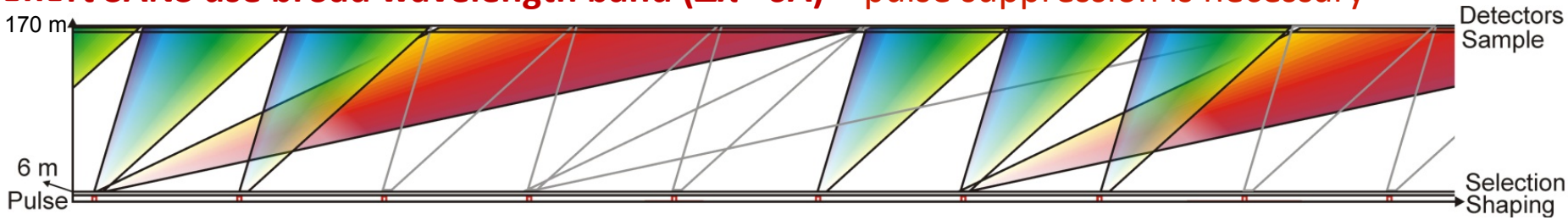
SANS related costs: 3.5 M€

Running the instrument

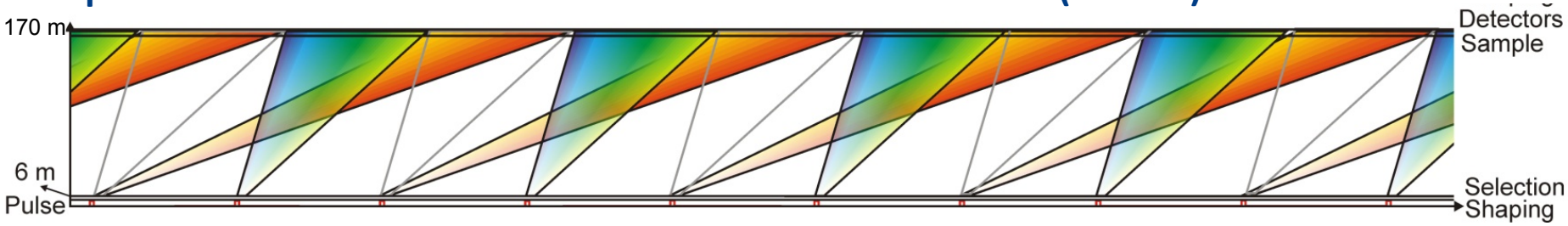
Pure diffraction mode: Thermal powder diffraction (0.6-2.3 Å)



Short SANS use broad wavelength band (Δλ ~6Å) – pulse suppression is necessary



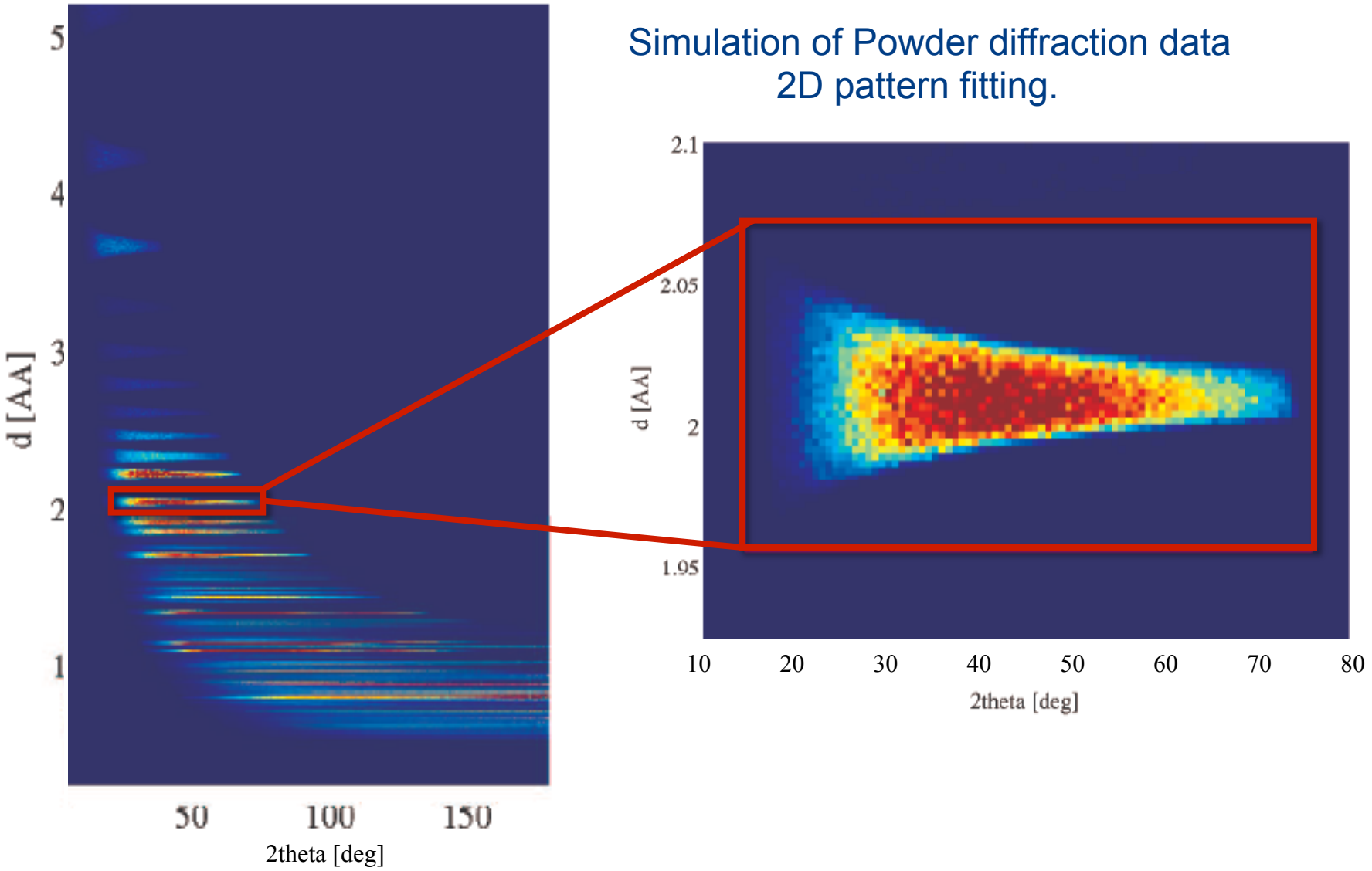
The powder detectors could be used for SANS measurements (4-5.7 Å)



Only single pulse suppression is necessary.

Diffraction setup

Simulation of Powder diffraction data
2D pattern fitting.

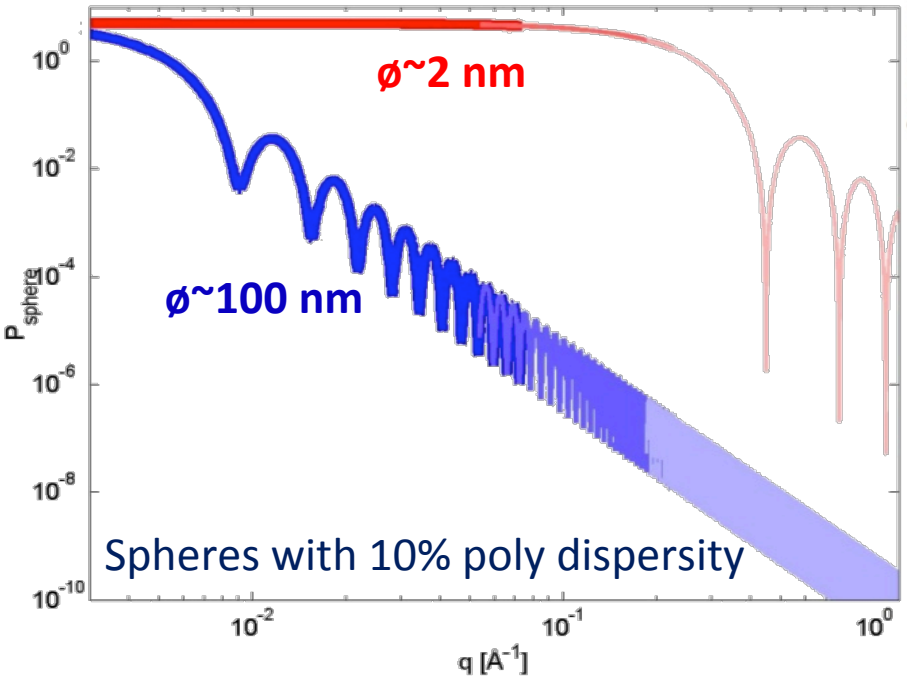


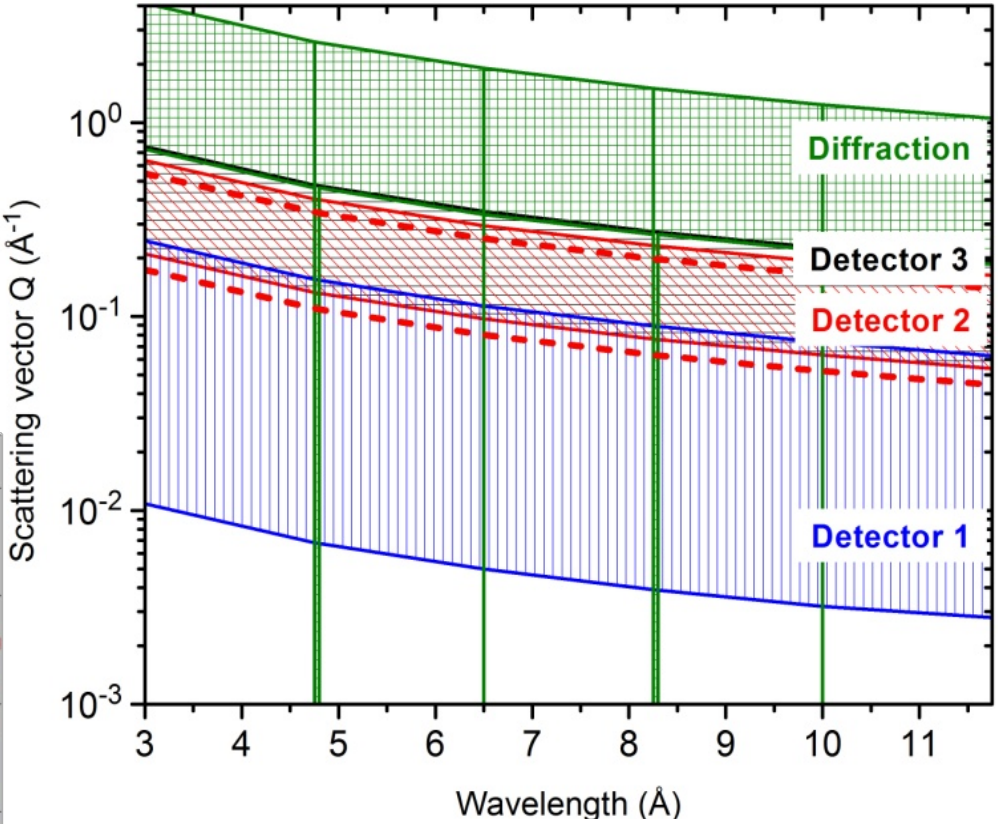
SANS detector setup

Beamstop:

Diameter 3 cm

20 cm from detector

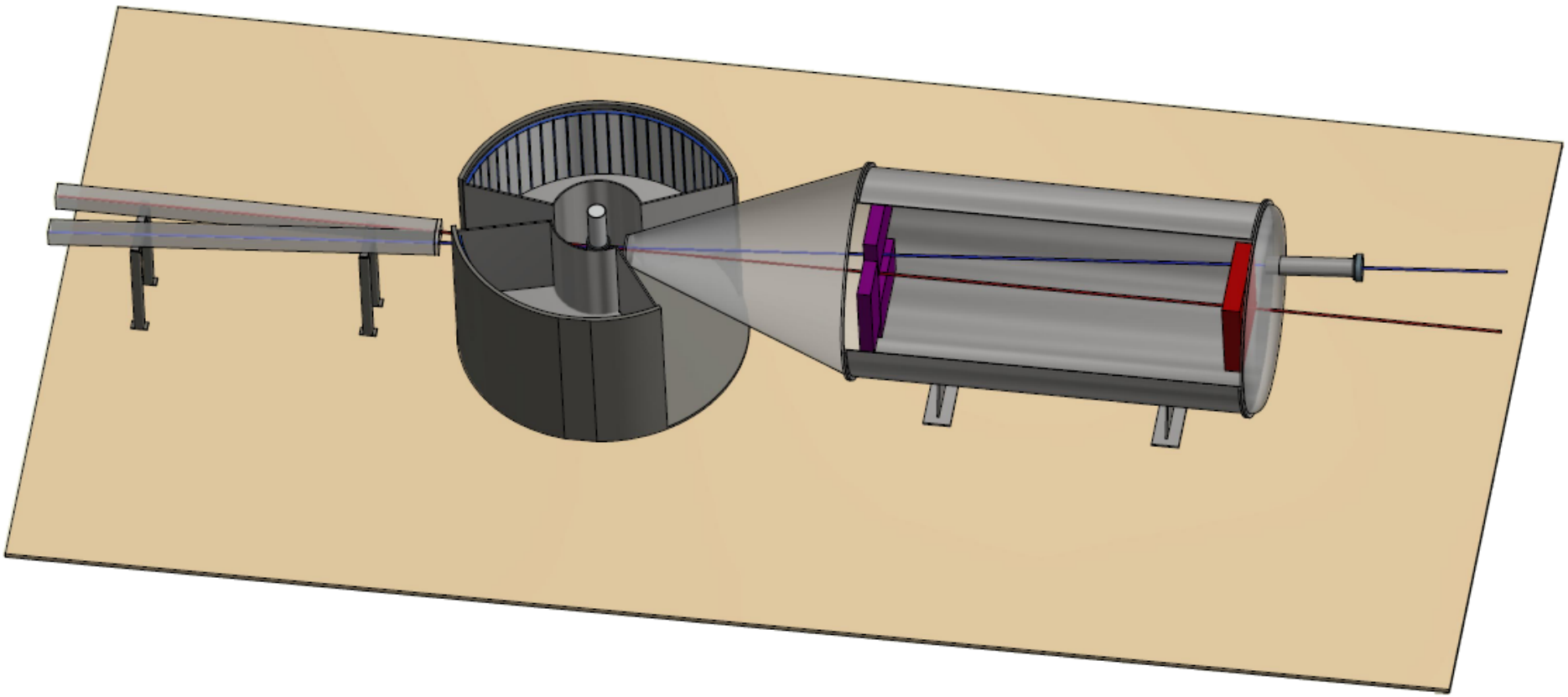




Good Q-range coverage even with single narrow wavelength band:

$\Delta\lambda$ = 10-11.7 Å

Should HEIMDAL be a day 1 instrument?

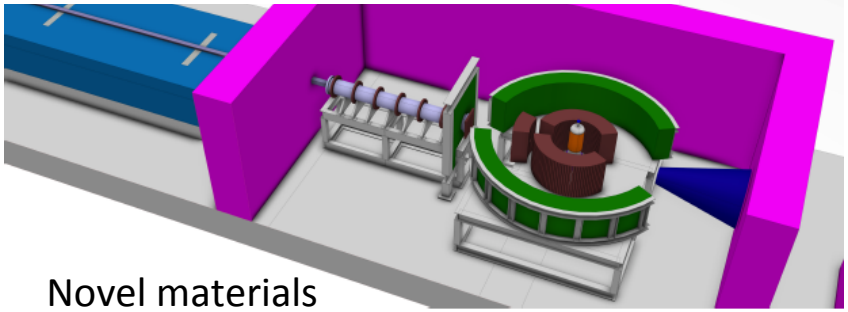


Day 1 instrument? …Yes

Science case in TDR v3

Structure & in-situ processing
Catalytically-active materials
Novel materials
Health & pharmaceuticals
Fuel cells
Battery materials
Gas storage materials
Solar cells & photovoltaics
Engineering & geosciences
Archeology & heritage conservation

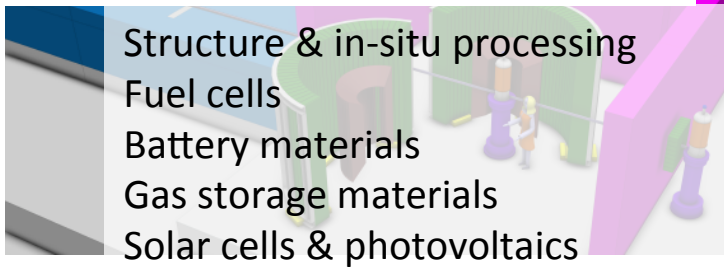
Thermal powder diffractometer



TDR v3

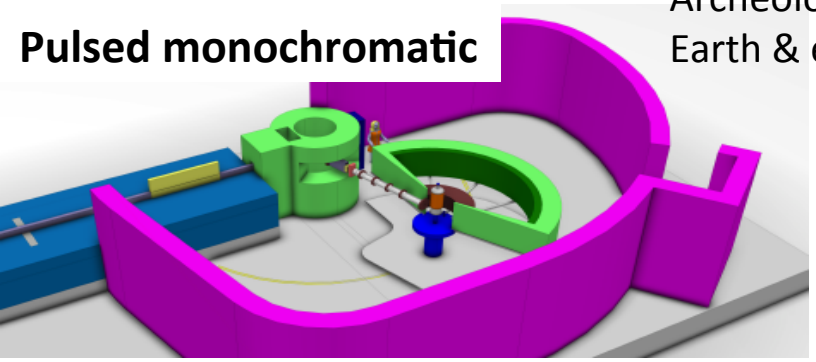
Novel materials
Structure & in-situ processing
Catalytically-active materials
Fuel cells
Battery materials
Solar cells & photovoltaics
Novel states of matter
Engineering & geosciences
Archeology & heritage conservation
Earth & environmental sciences

Bispectral powder diffractometer



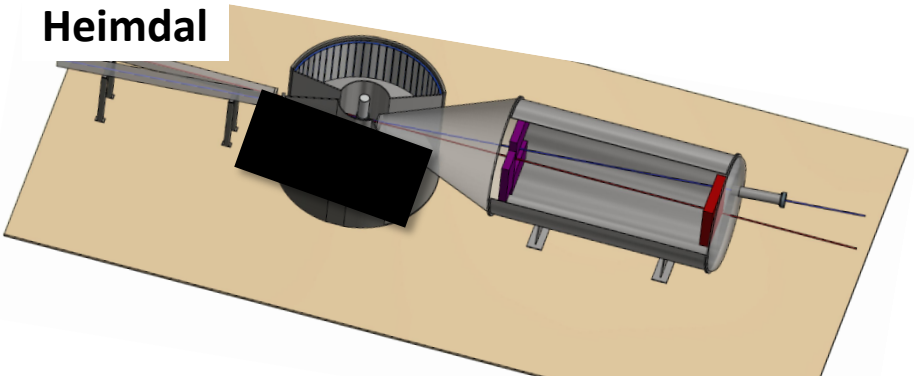
Structure & in-situ processing
Fuel cells
Battery materials
Gas storage materials
Solar cells & photovoltaics
Catalytically-active materials
Novel materials
Health & pharmaceuticals
Novel states of matter
Engineering & geosciences
Paleoclimatology & climate change
Earth & environmental sciences

Pulsed monochromatic

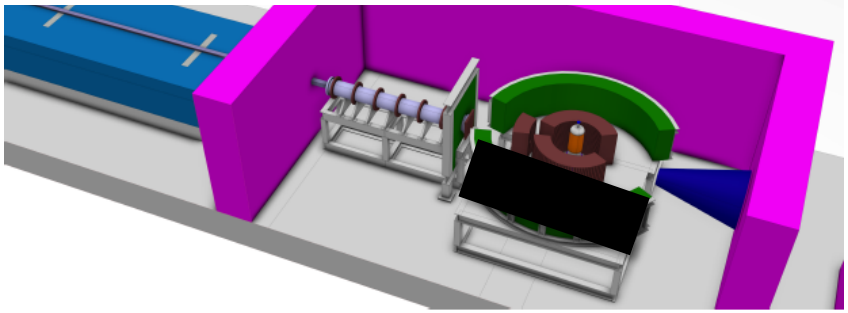


Day-1 powder diffraction instrument

Heimdal



Thermal powder diffractometer



HEIMDAL can cover the same science cases

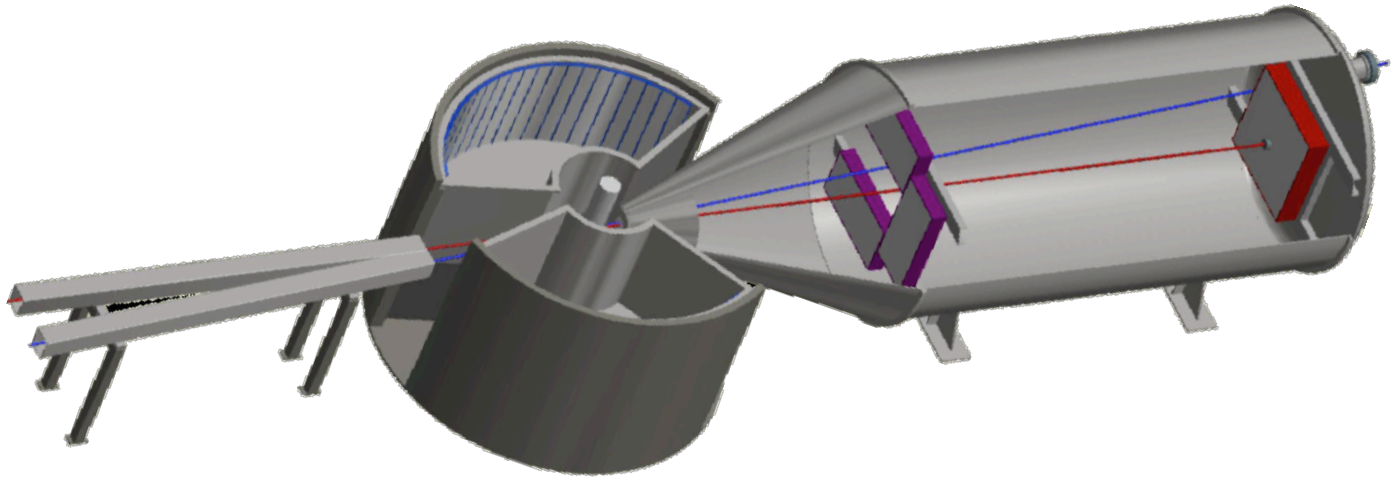
Plus broader length scales!

A day-1 instrument typically has
1 side covered by detectors
WISH, POWGEN

Structure & in-situ processing
Catalytically-active materials
Novel materials
Health & pharmaceuticals
Fuel cells
Battery materials
Gas storage materials
Solar cells & photovoltaics
Engineering & geosciences
Archeology & heritage conservation

The **pure powder part** of HEIMDAL is identical to the thermal powder diffractometer.

HEIMDAL as day-1 powder diffraction instrument



HEIMDAL is a novel concept:

- **Allows completly new science**
- **Performance similarly to Thermal Powder Diffractometer**
- **Has the potential to attract new users**

How can AU participate in the in-kind process?